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THESIS

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HYPertext:
ANOTHER STEP TOWARD THE PAPERLESS SHIP

by

Daniel A. Kellett

June 1989

Thesis Advisor:
Co-Advisor:

Professor Barry Frew
Professor David R. Henderson

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HYPertext:
ANOTHER STEP TOWARD THE PAPERLESS SHIP

by

Daniel A. Kellett

Lieutenant, United States Navy

B.S., Virginia Polytechnic Institute and State University

Submitted in partial fulfillment of the
requirements for the degree of

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from the

ABSTRACT

The original ideal of a Paperless Ship is a clear, concise, strategy statement that mandates paper reduction and office automation on ships. Its intent is to alleviate combat units of the serious limitations imposed by paper. Nevertheless, paper eradication is not desirable per se. Rather, what is important is to develop a library of knowledge, electronically stored for shipboard use. This thesis shows how using Hypertext for information retrieval fills a gap between MIS and Decision Support for unstructured problem solving. By implementing the Boiler Water Feedwater Test and Treatment Manual, Volume 1 in Hypertext using GUIDE and low end Personal Computers, this thesis demonstrates that electronically stored documents capture efficiencies not possible in hardbound text. Whether or not Hypertext can successfully eliminate all paper is arguable, but irrelevant. This thesis demonstrates that for the user interface, Hypertext is a desirable retrieval system because it is simple, and friendly, and has a familiar look and feel.

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I. INTRODUCTION

Why Paperless Ships? The idea of a Paperless Ship sounds simple. But it is not as simple and clear as the phrase suggests. Paper eradication may not be possible or desirable. A policy directing all Naval vessels to be paperless implies more than merely reducing reliance on paper as a medium; yet reducing reliance on paper may be a more realistic approach. Recent arguments supporting the desirability of paperless ships center on the limitations of paper as a means of storing information. Current research within the Navy focuses on the mechanics and technology of mass storage and electronic storage devices. There is a lot of discussion about the benefits of electronic storage, and about the existing devices for achieving electronic storage. But there is minimal discussion about whether electronically stored information is more useful than information stored on paper, and about how best to retrieve information stored electronically.

The purpose of this thesis is to assess the feasibility of managing information retrieval within large information systems using Hypertext. This thesis conducts a thorough review of the literature concerning Hypertext, applies Hypertext to static reference material within the Surface Ship Engineering Department environment, and constructs a working

model using Hypertext on an IBM-compatible computer and using unclassified engineering reference publications.

The model demonstrates the potential for electronic Engineering Department libraries. The purpose of producing this model is to demonstrate how these manuals look and feel.

The model communicates, visually, the concepts underlying a user interface with Hypertext. As a prototype, the model helps the author examine the feasibility and usefulness of this emerging technology. While attempting to answer how Hypertext based systems improve the shipboard environment, the author will attempt to discover the relevant issues when implementing Hypertext. Providing a copy of the Boiler Water Feed Water Test and Treatment Manual, Volume 2 on floppy disk in Hypertext format to the uninitiated allows them to experience and to use the model to better understand Hypertext. Conclusions will be drawn from the model on the feasibility, adaptability, and requirements of Hypertext retrieval systems and on their application to the Surface Navy's on-board information systems.

The model demonstrates that operating systems, computing power, computer architecture, and resident memory size are not critical considerations when implementing Hypertext. The prototype hardware consists of an IBM XT clone, with one 360K floppy disk drive, a 20 Megabyte Hard disk, a mouse, and a monochrome high resolution monitor running via a hercules monochrome graphics card. The Hypertext prototype manual is

stored on floppy disks. Using a commercial Hypertext software package called GUIDE, the model will demonstrate that Hypertext can be implemented on low-end personal computers. The speed of searches, retrieval, and string matches increases with better hardware, but does not depend on them. Hypertext is not hardware dependent; it is concept dependent.

Hypertext captures and emulates the way people interact with information. Just as linear text is a concept designed for paper, Hypertext is a concept designed for electronic media. Hypertext allows the user to retrieve all of the information he is interested in--instantly--retrieving only the text the user defines. It is a way to electronically archive, to rapidly access, and to retrieve information. Hypertext is an existing technology, tested and proven through numerous applications. It is potentially useful as the foundation for shipboard libraries.

In short, Navy policy and the disadvantages of paper in a shipboard environment necessitate an electronically based information system for ships. Hypertext is very capable for long-term storage of static reference material. It is uniquely well suited for dealing with users who wish to access reference material and for storage and retrieval of graphics, drawings, examples, pictures, text, annotations, and data. Hypertext stores information in a form that is rapidly and immediately accessible to the user. It dramatically reduces the labor required to handle knowledge and facts.

This thesis demonstrates that Hypertext is a feasible means for managing and using an automated document system. The information considered is static reference information produced by shore facilities for Engineering Department shipboard libraries. Transaction processing systems are not included in this study. This research focuses on how static reference material can be stored electronically to capture the advantages of electronic media for information retrieval. This thesis identifies the requirements and pitfalls of using Hypertext retrieval systems instead of paper media as an archive for Engineering Department static documents. The conclusions of this thesis can be applied to all departments on the ship that use static reference material.

II. THE MANDATE FOR A PAPERLESS SHIP

What is really meant by a Paperless Ship? The phrase conjures up images of a utopian organizational environment, where reports are completely automated and personnel no longer carry pens and pencils. Everyone is free from the slavery of administration on board a ship where forms, reports, in-boxes and out-boxes no longer exist. Upon hearing the words "Paperless Ships," the listener is inclined to immediately envision paper eradication: "no more paper on ships--period!"

Is paper hindering mission effectiveness so badly that the paper itself is an anathema? Before the Navy's concept of paperless ships, civilian industry envisioned the paperless office. Since paperless offices were first conceived in the early 70s, businesses have continued to dream of, and to fail at, achieving them. The "paperless office" as a phrase survives as a paradigm for "the future of computing--the office of the future" (Strassman, 1985, p. 165). But, the entire concept has proven to be a red herring in the area of information technology. Computers do not always reduce reliance on paper but can retrieve information faster, cheaper, and with greater accuracy than people can. Timeliness of information is a far more critical issue than paperlessness: paper is cheap, while timely information on paper is not. Rapid retrieval of information, requires

electronic processing and electronic processing requires moving away from reliance on hardbound text.

Reducing the reliance on paper is easy to articulate but not easy to achieve (Strassman, 1985, p.165). Within the Federal Government, paper--and the proliferation of paper--is a serious issue warranting Congressional attention. In 1980, Congress passed the Federal Paperwork Reduction Act (Strassman, 1985, p. 168). Federal law mandates reducing reliance on paper as a medium for government transactions. Whether or not advances in the technology of storage media or federal legislation are the catalyst driving the Navy vision of the paperless ship, the Navy in 1986 adopted a policy of paper reduction and paperless ships.

The mandate for a paperless ship came from then Vice Admiral J. Metcalf III, acting on behalf of the Chief of Naval Operations, in part from personal observations (Department of the Navy, Office of the Chief of Naval Operations, Memo 03/DU2211, 24 December 1986). While aboard the USS Bunker Hill (CG 52) the Admiral observed "half a dozen technical libraries" staffed by highly paid uniformed technicians performing as full time librarians, buried in paper. His own investigations verified that the Bunker Hill experience was typical throughout the fleet and the source of declining morale within the Surface Line community. He sponsored research to identify precisely how critical the problem of

information overload had become throughout the Navy. (MacDonald, 1987, pp. 14-16)

Researchers have found that manual information systems using paper media in the Surface Navy are not very useful and require much labor and paper. For these reasons, such manual systems impair the Surface Navy's ability to achieve its mission. Therefore, the Navy wishes to eradicate as much paper from the shipboard environment as possible. Nevertheless, the Paperless Ship is a simplistic view describing what many conceive to be an "instant remedy" to current organizational inefficiencies. In reality, a more accurate description of the underlying goal is to reduce the man hours and costs associated with processing and handling shipboard administration (Strassman, 1985, p. 166). Paper should not be the concern; rather, the concern should be improving organizational effectiveness through the appropriate use of technology. This means using paper where paper does the job better, and using electronic systems where they do the job better.

Until recently, paper has been adequate for storing, managing, and retrieving information. But the information explosion has made paper a constraint to information management (Chickering, 1988, p. 227). If human interaction with information is thought of as a dynamic process involving repeated examinations and interconnections of scattered parts, then hardbound books are not very satisfactory. The reason is

that books are passive. Book users must know how to access the information requiring retrieval because the books cannot take an active part in the retrieval. (Licklider, 1965 ,p. 5) Currently, the printed page is a long term storage device, and limits interaction; however, as a short term storage device it could enhance interaction. Electronic media should be used to archive information, and paper should be used to capture information retrieved electronically. (Strassman, 1985, p. 177).

As a medium, paper has distinct advantages. It has high resolution, and contains enough information to occupy a reader for a specified period. Paper is flexible, small, light, movable, cuttable, clippable, pastable, replicable, disposable, and inexpensive (Licklider, 1965, p. 4). Paper proliferates because people currently prefer communicating with it rather than with video screens. Therefore, if people are to use substantially less paper, they must be willing to use electronic systems. Paper currently has two distinct advantages over video display: first it is portable, and therefore can be easily read without restricting the reader to a particular location or position. Second, paper is less tiring to the eyes (Strassman, 1985, p. 169).

But paper also suffers from distinct disadvantages relative to electronic media. Storage on electronic media requires negligible physical storage space. Processing with electronic media is more accurate and less redundant, and allows greater

flexibility, than paper media. Electronic media are far superior to paper for storing, retrieving, organizing, and using information. Paper is bulky and heavy. Paper tends to contain redundant information. ~~Because~~ Because hardbound text is designed for a broad based audience rather than for a specific reader, retrieving information requires the reader to review the general before uncovering the specific (Licklider, 1965, p. 4). The reader must search the irrelevant before finding the relevant. Paper stores information sequentially and linearly, thus requiring the reader to move through the information sequentially, from one sentence to the next, one paragraph to the next, and one page to the next. Electronic media allows information to be stored by abstraction, ideas, subjects, relationships, and key words, and does not require sequential organization. Electronic media allow immediate extraction based on the specific needs of the reader.

Moreover, paper has other disadvantages unique to ships. Because ships are floating platforms, the placement of weight is a critical consideration in ship design. As much as 21 tons of paper and containers for paper storage reside on one Oliver Hazard Perry class frigate, and on an Aegis class cruiser the figure approaches 37 tons. (Russell, 1987, p.12) Paper represents uncontrollable weight and 21 tons of uncontrollable weight is a serious problem. The uncontrolled proliferation of paper greatly reduces a ship's stability. As much as one-third of the weight in paper tends to exist

above the main deck, an area particularly sensitive to changes in weight. (Chickering, 1988, p. 228) Weight increases fuel costs necessary to move a ship through the water. Paper also hinders damage control by fueling fires and clogging pumps. Large quantities of paper on ships reduces the safety of the vessel.

Paper is bulky and volume intensive, and ships are severely limited in storage space. Assuming paper has a density of 40 pounds per cubic foot, 14 tons of paper occupy 700 cubic feet. 700 cubic feet is the equivalent of a 10 x 10 foot room with an 8 foot ceiling. Thus a Perry class frigate loses the equivalent of two 10 x 10 spaces just to store paper. The time to retrieve information increases the number of personnel required to manage a ship properly. Every person added to the ship's company for processing paper also adds a requirement for food stores, living space, and personnel upkeep. As crew requirements increase, the cost of operating a ship and the space required to maintain the crew increase. The space occupied by paper and personnel to process paper is space not available for combat systems. (Chickering, 1988, p. 228)

Improving combat capability and operational effectiveness of ships is the driving force pushing for reducing reliance on paper aboard ships, but it is not the only force. Replacing manual shipboard information systems with automation implies replacing metal filing cabinets with electronic filing systems, replacing paper mail with electronic messages,

replacing people with machines--each significantly reducing the costs involved in handling communications while simultaneously improving organizational performance and productivity. Paper is cheap, but processing it is not. Lost capabilities, lost space, lost labor, and lost accuracy are all costs associated with the use of paper aboard ships. These costs are what make paper systems expensive and justify reducing reliance on paper based systems. (Strassman, 1985, p. 168) The real goal of the Paperless Ship should not be to eliminate all paper from ships, but rather, to eliminate only those paper based systems that can be handled better electronically.

III. ELECTRONIC STORAGE AND REFERENCE MATERIAL

Before a paperless ship can be a reality in the Navy, a retrieval system must be in place and be able to handle the information requirements of the ship's crew and the ship's decision makers. People have to believe electronic systems are better than existing paper based systems if they are to use them instead of paper. Ideally, the system must be simple to use and available to all types of personnel. The crew members and decision makers who need information from the system may be unskilled in electronic media and may not be sure of the exact approach necessary to access the information required. Having gained access electronically, they may want to shop for options and may be uncertain of key words and addresses necessary to continue the search. Fast retrieval of information, either linearly, or conceptually (through ideas, relationships, key words, key phrases, or graphical representations) aids memory recall and makes information stored in shipboard libraries more accessible and useful. An electronic system which supports these characteristics is better than a paper system at identifying the relevant options and the potential solutions.

The sheer volume of reference material aboard ships severely handicaps its crew. In paper form, there is not a timely and efficient way of accessing the contents of large

libraries. The cost of retrieval remains very high. Time is valuable, and crew members using paper tend to ignore information which is not readily accessible. Of the total paper carried on Navy ships, 55% is reference material. (MacDonald, 1987, p.15) For example, the engineering department will carry at least the following: engineering drawings, technical manuals, rules and regulations, letters of guidance, training documents, maintenance requirements, archives of messages, forms, standard procedures, and material history. (Chickering, 1988, p. 226) If just the static reference material carried on a ship were stored electronically, a significant amount of paper either could be removed from ships or, at the very least, could be removed from logrooms to fireproof storage spaces as a backup in case of power failures. Nevertheless, the main value added by electronic storage is not the removal of paper from work spaces or ships, but the speed of access to information that used to be on paper.

By reducing the time required to retrieve information, electronic storage of reference material can improve the quality of decisions. Reducing the effort required to retrieve information releases a decision maker from the laborious task of "looking things up," allowing more energy for the decision itself. If Navy decision makers can centrally warehouse knowledge and retrieve all the information applying to a decision easily and rapidly, they will

significantly improve response time for all decisions. They will have more time to consider a greater number of options.

Reference information originates at shore facilities for shipboard use with updates generally occurring quarterly. Each ship is a floating library of documents containing the information that staff and support groups consider necessary for the proper conduct of the ship's business and administration. The total store of information is the direct result of an individual ship's information requirements. Therefore, shipboard information is bounded in size and scope by the ship's individual information requirements defined by ship type, mission, and resources. Ships receive only those portions of publications and volumes necessary to meet the individual ship's needs.

Accessible information is critical to operating ships efficiently, and requires organizing, indexing, and abstracting the body of knowledge and facts. The type of information requiring storage and processing, and the type of users accessing it, will require a different approach to retrieval than the current query and browsing techniques of database management systems. First, support of unstructured browsing and unstructured problem solving requires access in a manner that emulates the way individuals think. But database management systems perform access on the basis of the system's design and do not support all of the user's preferences or personal methods of search. Second, users may

not be familiar with the publications or the subject for which they need information. But database management systems require a degree of knowledge and experience with the stored information in order to access it. Therefore, the shipboard environment requires a retrieval system that can process large volumes of information and that can also support rapid access from unstructured and conceptual views. It must be simple to use. It must not be bounded by purely linear approaches because crew members often do not approach information linearly. The system must be able to support the immediate access to, and retrieval of, information tailored exactly to the user's needs and preferences. Hypertext can fulfill all of these requirements.

IV. WHAT IS HYPERTEXT?

Hypertext is a macro-literary system designed for storing large on-line libraries of information including interconnected documents and machine-supported links. (In Hypertext, machine supported references are called links and the links join one thought to another by allowing the user immediate access to any thought on the other end of a link.)

Hypertext allows a complex organization of information. The information is stored as a combination of blocks joined together by links. Computers access blocks by following the links from one block to another. Systems can be designed so that all publishing, reading, collaboration, and criticism take place on a network containing the Hypertext system. The system can also be designed without a network. The Hypertext system is dynamic: continuously adapting and expanding. It allows for user input, growth, and changes in knowledge without requiring system redesign or changes. Hypertext can also support unstructured thinking on a problem when many disconnected ideas come to mind.

Hypertext is software based on a conceptual view of how information should be managed within a document retrieval system. It is not a program, or a language, but rather a classification of software with specific characteristics. Just as software referred to as "word processors" or

"spreadsheets" conjures up images of specific attributes common to all software of those classifications, so too, Hypertext conjures up images of specific attributes belonging to it. In other words, Hypertext is a way of viewing information and a specific way of constructing it. Hypertext, just like the printed page, is a medium of communication.

A. ATTRIBUTES OF HYPERTEXT

Using Hypertext, a user can retrieve a hierarchy of detail on subjects as well as individual comments and annotations. Specific ideas or sentences can be summoned in their original context. Also, articles, books, units of text, letters, footnotes and bibliographies related to the idea, and the context of the idea, can also be summoned. A user can explore specific, general, or related areas of interest as well as moving to new ones without having to phrase the question precisely. (Nelson, 1967, p. 186) Without leaving the document and without having to leave the area of interest, the reader has immediate access to all of the related information on a subject contained within a system.

All Hypertext systems contain some form of browsing aides like indexes, tables of contents, graphical displays, windows, and icons useful for teaching, referencing, and accessing ideas with maximum ease and minimal training. Currently, Hypertext simply refers to the use of windows--or gateways imbedded in textual and graphical images--connecting

associated objects in a database. Connections are achieved by using links provided between objects. Links can appear as graphical representations (as labeled tokens) or as highlighted text. But regardless of appearance, links are simply pointers imbedded in the database. They point to whatever exists in the database that can be associated with the original object. (Conklin, 1987, p. 20)

Unlike current database design, there is a direct link between each piece of information contained in a document being viewed and each other piece of information related to it contained within the database. The user has direct access to all of the information all of the time, provided the information is linked. Links are constructed based on context and relationships between ideas. Therefore, Hypertext is sometimes referred to as an idea processor. (Conklin, 1987, p. 17) Processing ideas requires the creation of what, in Hypertext applications, is called the hyperdocument.

B. HYPERTEXT MUST HAVE A HYPERDOCUMENT

The hyperdocument is what database systems would call the database; however, in Hypertext the hyperdocument is the underlying textual, graphical, audio, or video information the system communicates and to which the links give access. The hyperdocument cannot be printed because it is not sequential. It does not exist in any particular order. The hyperdocument is not linear, but is unstructured pieces of

information that find structure only through the demands of the user. Hyperdocuments are hierarchical when a hierarchy is required, linear when linearity is required, and devoid of structure when unstructured browsing is required. Hyperdocuments structure information by relationships, not by a specific progression of thought.

What separates Hypertext from textual databases (document retrieval systems and concept retrieval systems) is the hyperdocument. Like a database management system for relational databases, Hypertext stores all pieces of information in a central location (the hyperdocument) and then allows access to those pieces by relationships. Hypertext is not the storage of documents as flat files accessible through key fields; rather, it is the storage of all of the pieces making up the documents as one document. Access to each piece is attained through whatever links point to it from different parts of the document. File-based systems do not allow navigation within a document, between documents, and across concepts. Outline systems will not support links between outlines. (Conklin, 1988, p. 18) The hyperdocument allows movement across any definable relationship. It is a network of text and graphic nodes (chunks) which, taken together, equal the available accessible information.

Hypertext systems are closely related to information databases. Hypertext is inappropriate for transactional

databases because transaction processing systems require a data orientation, whereas Hypertext systems are knowledge oriented. Transaction processing systems are designed for repetitious day-to-day operations. They are "repositories" of data that exist for the express purpose of establishing information via recall, manipulation, and analysis. (Rockart, 1978, p. 83) Hypertext, however, is not designed for repetitious or routine data-processing common in transactional systems. It is designed specifically for reference of knowledge and facts. Hypertext allows for rapid search, and the unique ability to access information from anywhere within a piece of text or a graphic. It can retrieve information directly from reference points contained in indexes and tables of contents as well as from reference points imbedded directly within text or graphics.

C. HYPERTEXT MUST HAVE CHUNKS

Hypertext can be partially visualized as an electronic notecard system. A notecard generally contains a single topic or single piece of information combined with some system of reference. The electronic notecards in Hypertext are referred to as "chunks", "frames", or "nodes". Information is divided into small units (chunks, frames, nodes....) containing text, graphics, sound, or animation. Units of information exist like stacks of notecards, each containing references to other notecards retrievable either sequentially, through indexes,

through file markers, hierarchically, or through immediate cross referencing from one notecard to another. Hypertext is a system in which direct machine supported references from one "chunk" of information to another give the user the ability to interact directly with the chunks allowing the user to establish new relationships between them. (Conklin, 1988, p. 17)

Each small unit of information is displayed, one per window, with systems varying by the number of windows permitted to be displayed. These small units are chosen for display through a series of interconnected links. Users navigate through the units by selecting links. Creation, deletion, and editing of units allows users to create "tailored" systems. Networking the system, as a shared system, allows multiple users to access the Hyperdocument. (Ascyn, McCracken, 1984, p. 903)

Hypertext stores "chunks" of information as a database management system stores data. Just as key fields in databases can access any information in records that have the key field, a particular chunk can access any information in other chunks that have links connecting to it. Unlike databases, chunks do not have to be alpha-numeric. They can contain anything that a machine can identify and will fit within the boundary of a frame. A chunk of hyperdocument--the notecard--is not defined by size but rather by concept. Theoretically, the notecard can hold any amount of

information; nevertheless, most current applications use the screen size as the limiting factor.

D. HYPERTEXT MUST HAVE LINKS

A link is a pointer embedded in the hyperdocument that points from one position in the hyperdocument to another position. A link is a jump from one block of information to another. For a user to connect information together, he requires a link between the two pieces of information. Each link can access only a single piece of information. The user makes the link based on any identifiable relationship that the two pieces of information have in common. Links insure that each item within a particular unit of information is related to all other units of information contained within the hyperdocument that are related to it.

Links, as they apply to Hypertext, have the same attributes and types as semantic nets have in expert systems. In programming languages, defining the "type" that a variable will be is an important part of establishing the properties the variable is allowed to have in operations. This is the notion of inheritance. Operators inherit capabilities by their type. For instance, if an operator is type "real number", then the operator inherits the property of addition, subtraction, multiplication, and division. Artificial Intelligence uses the same notion of inheritance semantically through the use of semantic nets. For example, a dog is a

mammal, thereby, dogs inherit the properties of all mammals. In Hypertext, the inheritance occurs through the typing of links. Links can have properties. For example, a link can be type footnote, or type reference. Links can be critiques, or supporting views. The author of a Hyperdocument decides on the types of links that will connect each piece of information. The development of a hyperdocument depends on the author's choice of links and chunks. It depends on the knowledge the author wants to communicate, not on data structure.

E. HYPERTEXT USUALLY HAS ICONS

The user views the information (the chunk) and a window showing the "icons" (graphical representations). These icons represent links to other chunks related to the one being viewed. Each window contains a set of these "link icons" pointing to other information related to the current window. The link icon depicts the type of reference it links to. Links on the screen correspond to the available chunks, one-to-one. "Clicking" on the icon retrieves an associated bit of information and all of the icons related to the new piece of information. Information on the screen can also be gateways of access that use embedded "buttons" underlying an element of information contained within the chunk. These gateways give access to topics related to that element.

By moving through the windows, the reader moves through the hyperdocument. But, to move through the windows, the reader must select icons or gateways; therefore, presentation depends on user choice. (Conklin, 1988, p. 18-20) The hyperdocument can also be browsed by navigating through the hyperdocument using the "browser". The browser is a graphical display of the network representing the document. It is like a map. The browser is an essential feature that prevents getting lost in the document by presenting a graphical view of where you are in relation to the rest of the document.

Without a graphical view for organizing the structure of nodes and links, most hypertext systems display no structure and consequently communicate very little knowledge.

F. HYPERTEXT NEEDS BROWSERS

Current research in Hypertext emphasizes structure and how to prevent getting lost in the spaghetti of links and icons that Hypertext generates. Information is knowledge without structure. Knowledge, however, is information with structure (Bush, 1945, p. 101). If Hypertext systems are to communicate knowledge, structuring the information is critical in developing the hyperdocument. But structure must exist without affecting immediate access to ideas and concepts. Current Hypertext applications and theory too often allow the user to become lost in the information he or she is browsing and then later to be unable to repeat the same steps of

access. For Hypertext to be effective in communicating knowledge, a path to knowledge, once found, must be easy to repeat.

G. HYPERTEXT IS UNIQUE

Because information can be accessed without any knowledge of the underlying links or system, Hypertext should be thought of as idea processing (Conklin, p.33, 1987). It is a computer-based medium for thinking about and communicating knowledge. Access is based on context and on relationship, not on data structure or on equivalency. The user must know what he or she is looking for, but not exactly where it is or how to locate it. Hypertext allows browsing ideas without having to extract the idea from unrelated text, as is required by paper text.

In summary, Hypertext is not a database method. Peculiar to Hypertext is the unique direct access to blocks of information achieved by way of controlling buttons imbedded within the content of the material or by way of reference icons displayed on the current window. Hypertext allows access without knowledge of the key fields involved and without construction of fields and data structures. Any data of any type can be stored in a "chunk". Access depends only on relationship, and not on similarity. Hypertext is a way to store knowledge and to have direct access to it from virtually any conceptual angle. (Conklin, 1988, p. 33) The linkage

capability allows non-linear text to exist. Window systems have no single underlying database because the entire system is the database--the hyperdocument. Links are established throughout the hyperdocument. Hypertext allows navigation anywhere in the system to any other point in the system by following connecting links.

V. WHEN SHOULD HYPERTEXT BE USED?

Hypertext is a means to an end. The Navy does not need Hypertext per se; what it needs is sound information management. Sound information management implies accurate transaction processing in combination with decision support. Superior and effective decisions are those that are supported by expert advice. They are informed decisions arrived at through an understanding of the related background information in numerous technical and administrative areas. Where a fixed-context retrieval system like a transactional processing system or a data base management system, supports the user's needs for information, nothing else should be provided. (Nelson, 1967, p.200) But where it does not, dynamic interactive systems like Hypertext can fill the gap. Hypertext can augment existing systems, but it should not replace them.

Hypertext does what other applications cannot do. It fills a void in the current framework of Information Systems. Hypertext presents information that Electronic Data Processing (EDP), Management Information Systems (MIS), Expert Systems (ES), Decision Science, and Decision Support Systems (DSS) cannot. Hypertext does not displace any of these systems; it complements them. Hypertext is capable of database management, of generating spreadsheets, and of word

processing. But, Hypertext is not designed to do these things. It is designed for document presentation. Hypertext is designed for linking together the spreadsheets, reports, and results of other applications.

Currently, successful Hypertext applications have concentrated on the electronic storage of, and access to, reference material and procedural text and instructions. Hypertext systems designed to be dynamic on-line literary systems for collaboration and criticism are experimental and still evolving. Systems designed for literature have proven to be less useful: Art and Literature do not transform well electronically. But history, medicine, law, science, engineering, and technology do transform. Other documents like regulations, letters, guidance, policy, and maintenance also translate well, because Hypertext treats them the same way readers do--in chunks.

By discarding the unit of "document" with associated chunks of information stored in the hyperdocument, Hypertext emulates the way people use maintenance publications. Solutions are sought through browsing the publication with a particular problem or group of symptoms in mind. With reference material, processing means answering whether or not the material presented applies. The reader is seeking solutions to the present need. How the words are constructed and how the sentences flow is immaterial. Only the facts, concepts, principles, and ideas sought in the document matter.

The reader is not seeking abstractions but rather specifics. (Licklider, 1965, p. 70) For maintenance publications and technical manuals, the only content that matters is the specific information required to solve the problem at hand. (Nelson, 1967, p. 194).

Hypertext is capable of supporting decision making in unstructured problems. It excels in assisting the collection of large amounts of relatively unstructured information related to, or a function of, the current information. Combined with mechanisms for filtering, organizing, and browsing, Hypertext generates a better understanding of the existing knowledge on a subject. It is particularly useful for review of known information before solving unstructured problems. It is uniquely capable of assisting the user in sorting out and developing ideas for situations which have no optimal solution, only a "degree of understanding." (Conklin, 1987, p.24) Because Hypertext processes information based on a trail of links, typed by relationship and applicability, it is very useful in processing those questions that lack definition and structure. Hypertext does not decide what is true or false, but only what applies.

The type of information the government produces is readily transferable to Hypertext presentations. The Environmental Protection Agency currently uses a commercial version of Hypertext designed for personal computers to publish regulations and regulate underground storage tanks in the

United States. (Federal Computer Week, 1988, p.4) By publishing regulations in a Hypertext format, the EPA has found that Hypertext simplifies regulations through quick access to cross references and to explanations of rules. Rules and regulations produced by the government are easier to follow and to understand when a system of retrieval, explanations, and cross references is easily accessible. The Navy is a branch of the federal government, and like the EPA, functions within a similar structure of rules and regulations.

The value of Hypertext can be divided along two lines: its impact on productivity and costs, and its impact on the quality of decision making and on improvement in the work environment. Hypertext can join different types of information systems together: those oriented toward transaction processing and reporting, and those oriented toward support of management decisions. Hypertext fills a void other systems cannot by providing decision support through effective, simple, document and report presentations.

VI. WHY THE NAVY SHOULD USE HYPERTEXT BASED SYSTEMS.

The shipboard environment is both industrial and bureaucratic. These two characteristics compound the need for information. Shipboard operations require extensive technical knowledge, knowledge of regulations, administrative acumen, and experience. Combined with the need for information is the need to assimilate relationships among disparate pieces of information. The result can be information overload. Information overload can induce stress, and stress inhibits the effective cognitive processes of decision making by reducing the decision maker's ability to process information. (Smart, Vertinsky, 1977, p. 642) It is not clear that Management Information Systems (MIS), Expert Systems (ES), and so called Decision Support Systems (DSS) are reducing information overload and supporting unstructured decisions.

By definition, MIS support decisions that have structure and definition. MIS is an integration of EDP jobs by functions within the organization. EDP systems focus on the processing, storage, and flow of data at the operational level. They emphasize efficient transaction processing. Files for related jobs are integrated into summary reports for management. MIS integrates EDP, using EDP to provide information aimed at middle management. In MIS, inquiries

and reports are generated by extractions from the database that are the direct result of EDP operations. (Sprague, 1987, p. 12) However, there is a gap between what can be reduced to data and what cannot.

The Surface Navy faces this gap. The Surface Navy relies on a transactional processing system called SNAP (Shipboard Non-Tactical ADP Program) for shipboard transactional processing and administration. Although SNAP is currently meeting many of the EDP and MIS requirements of the crew, it is not meeting their needs for decision support. SNAP and transactional processing systems cannot support semi-structured and unstructured decision making. Semi-structured and unstructured decisions are decisions involving problems that cannot be described in detail before making decisions. (Scott and Gorry, 1986, pp. 55-70) Expert Systems and Decision Support Systems were developed as an attempt to support semi-structured and unstructured decisions. But whether or not any ES and DSS can be used to solve unstructured decisions is arguable.

To solve unstructured problems, the naval manager must continuously apply problem solving techniques. He or she must determine the best method for solving the problem at hand. If automated systems for assisting in problem solving do not mesh with the manager's own cognitive processes--they will be ignored (Rockart, 1979, p.82). This is often the problem with Expert Systems. ES are based on techniques developed

through research in Artificial Intelligence, and solve problems based on the input of rules and operators. In Expert Systems, the answers are dictated to the user without the user understanding or interfacing with the background information. Unlike Expert Systems, Hypertext leaves the choice of action and the decisions and questions to the user.

The performance objectives of a Decision Support System (DSS) are different from the performance objectives of EDP, MIS, and ES. DSS, theoretically, draws on transaction processing systems and decision modeling systems interacting with the total information system to support the decision making activities of the clientele. (Sprague, 1986, p.17) Therefore, DSS is partially the by-product of properly developing the EDP, MIS and ES of the organization. Nevertheless, DSS is distinct from EDP, MIS, and ES because it is characterized by retrieval, analysis, and presentation in combination with simulations, a model base, and optimization models. DSS focuses on supporting decision making at all levels of the organization. All knowledge workers must make decisions, whether they work in strategic planning, management control, or operational control. (Gorry and Scott, 1986, pp. 55-70) Although proponents of DSS claim that it will support unstructured as well as semi-structured and structured decisions, there is no evidence of success in supporting unstructured decisions. Contrary to their claims,

proponents of DSS systems cannot yet support unstructured decisions through Artificial Intelligence.

A feature of DSS that distinguishes it from Hypertext is that DSS is not a process or a particular design as much as an articulation of how various designs and concepts can be brought together into one system. Proponents of Hypertext systems make similar claims, but move beyond the vision of what a DSS is, and define the process by which the system achieves decision support. DSS applies database management, operations research, management science, and accounting techniques. (Sprague, 1986, p.12) Hypertext is where relational databases, artificial intelligence, and DSS all intersect. Both DSS and Hypertext focus on improving operational performance by supporting management activity at all levels of decision making. By speeding the process of recall, Hypertext reduces the time required for a manager to process information, reducing information overload. Retrieval becomes a one of a kind operation meeting a specific user's need. (Strassman, 1985, p. 174) Hypertext can act as the shell for a DSS by displaying, based on user selection, processed pieces of information connected by relationships.

The performance objectives for Hypertext systems are closely related to those of DSS. Because Hypertext presents information in unstructured ways to solve unstructured problems, it supports the human mind's ability to link objects by association. At any given time, the user is interested in

only a small set of knowledge to solve a small part of a problem. Hypertext facilitates thinking by presenting only the set the user is interested in, and thus helps focus on the issues. A DSS, with Hypertext as a shell, can aide in conceptualizing the problem and in narrowing the scope of the problem through user-friendly interactions with computer-based information systems.

In unstructured, undefinable problems, browsing the known information on a subject may be the only means of seeking a solution. In Hypertext, knowledge and information can be represented as an exploratory structure that the individual mind searches by means of a computer-aided display. The purpose of any retrieval system is to tell the user what he needs to know, giving short replies to discrete specific questions, thereby aiding the user in problem solving. (Nelson, 1967, p. 200) This is what Hypertext does well.

Whereas a DSS is based on a database or on a model base, Hypertext is supported strictly by the hyperdocument and by the hyperdocument's links between existing relationships. But Hypertext can behave like a DSS by linking the results of transaction processing, data base reporting, and model base reporting. Hypertext fills the gap between paper-oriented document retrieval systems, data-oriented Management Information Systems, rule-oriented Expert Systems, and model-oriented Decision Systems. Hypertext achieves Decision Support by linking the results of various processing systems

to the hyperdocument, and giving control of retrieval to the user. Hypertext gives the shipboard knowledge workers unstructured information retrieved through intuition. Users gain access to the information they need with less effort. Retrieval is tailored exactly to the user's needs, and can resemble the type of information gained through EDP, MIS, ES, or DSS if links are established to reports. By using Hypertext-based document retrieval systems to electronically store documents and reports, the Navy moves farther away from paper based systems, and closer to effective Decision Support Systems.

VII. DEVELOPMENT ISSUES CONCERNING HYPertext

One of the unresolved issues in Hypertext literature is how to develop software that users will accept. What method of system design is appropriate? While traditional systems analysis supports the development of structured and static MIS and EDP systems, Hypertext is not in any way like a traditional transaction processing system. It would be futile to develop data models of Hypertext systems, or to use data diagrams to ensure the capturing of all the important elements. Hypertext is not designed for data oriented operations. Developing Hypertext applications is similar to developing a DSS because the user interface of Hypertext behaves like a DSS. Both DSS and Hypertext require a definition of appropriate capabilities, not a definition of appropriate structure.

Developing either Hypertext applications or DSS differs from developing other computer-based systems because the effort is directed toward variety. The system cannot support only one subset of the process or any one particular process. It must support all phases of the decision making process of intelligence, design, and choice (Gorry and Morton, 1986, pp. 55-70). Decision support must aid conceptualization, not limit it to specific types. The elements of a decision (Intelligence-design-choice) may not occur in sequential

order, but support for each individual element must exist. Thinking occurs on several fronts at once, developing and rejecting ideas at different points and on different levels. Each idea depends on another. Hypertext tends to be unstructured because the association of ideas together tends to be unstructured (Conklin, 1987, p.32).

Hypertext systems support unprogrammed decisions. Unlike programmed decisions, unprogrammed decisions are characterized by a greater need for participation, recognition, definition, and understanding. Pursuing only one right solution is inappropriate for unprogrammed decisions. The individual decision maker must search the environment using the resources available while striving to discover as many viable alternatives as possible without rejecting any. The path to a decision is the path that reduces the choices, implements one of the choices, and later evaluates that choice through feedback and control. (Gorry and Scott, 1986, pp. 55-70)

Hypertext and DSS are most useful when they capture variety. Designing a system for specific decisions reduces the number of decisions it can support. Because unprogrammed decisions are unpredictable, support of unprogrammed decisions should focus on decision tools rather than on decision types. Because decision aids are for personal use, they need to emulate the way users intuitively arrive at decisions. (Soelberg, 1967) Use of memory aids such as computer-based scratch pads, memos, graphics, and spreadsheets, all

contribute to identifying the alternatives available without having to identify a single one as best. Because levels of skill and knowledge, and style differ among decision makers, the system must be able to support each rather than capture a particular pattern. There are a wide variety of decision processes. Hypertext can support that variety because Hypertext can take on whatever attributes the user selects.

Developing Hypertext systems requires identifying how the designer wants to display documents and what purpose the system serves. There are numerous ways of applying Hypertext concepts. Like programming languages, the purpose of the application determines the type of Hypertext System that develops. Some systems are designed with a network of users in mind, each adding comments to the other's work, a network of researchers and academicians in a vast on-line library, for example. Others are designed to be interactive publishing systems that allow literature to be critiqued on-line without being defaced. Other designs support unstructured thinking to facilitate problem exploration. (Conklin, 1987, p.20)

Regardless of how Hypertext concepts are implemented, the thrust and focus of Hypertext applications is on communicating knowledge. (Larson, 1987, file 56) Current commercial Hypertext applications emphasize three principles. First, information is organized by idea and by context. Second, navigation through information is attained with a minimum of keystrokes and of training. Third, each use of the system

confirms or expands the user's understanding of the knowledge and of the relationships in the system. (Larson, 1987, file 62) Because Hypertext concepts closely align with the concepts articulated in the research of Decision Support Systems, designing the user interface for Hypertext applications will follow paths similar to those in DSS.

VIII. DEVELOPMENT ISSUES FOR THE NAVY

Most discussions of Hypertext become entangled in visions of vast networked literary systems spanning the globe. The Ted Nelson vision of an entire world on hypertext networks has no current real application in the Surface Navy. Fortunately, for Hypertext to be useful on Surface Ships, networks are not necessary. In 1982, a Hypertext application known as ZOG was put on USS Carl Vinson. ZOG was perhaps the best, largest, and most thoroughly tested Hypertext system in service today. But ZOG made its name more as a bulletin board and as a textual database tool than as a networked interactive database. ZOG illustrates the fact that Hypertext does not have to be interactive. (Conklin, 1987, p. 26) Networking users so they can share information from reference publications is simply not necessary in the Surface Navy.

Stand alone systems can be a first step in the development cycle of Hypertext based information systems. The access to, and retrieval of, information can be limited by department requirements. The information stored on each stand alone unit can be dictated by the current Navy distribution system. The Navy has, over the years, developed an extensive filing, subject numbering, and indexing system of its knowledge. A traditional pattern of distribution, and a definition of who should get what publications already exists. Which documents

should be stored on which disks can be defined by the design of the ship and by the department receiving them. The Navy has already determined what reference information must belong to which departments. Providing everyone on the ship access to everyone else's information should not be a Navy goal. Because the Navy's long held tradition is to give information only to those need to use it, networking and allowing users to write onto documents are not relevant to the Surface Navy dilemma.

Government, and its ownership of public information, is uniquely poised to take advantage of Hypertext concepts. The government does not have to worry over copyright issues because the government owns the information it produces. Therefore, fractured pieces of information borrowed from one source into another do not have to maintain authorship. Arguments on how best to preserve copyright information and give credit to authors for specific chunks of information do not apply to the Navy. Every document that leaves a ship is credited to the commanding officer, and every document that enters a ship comes from some other accredited commanding officer.

Therefore, the system needed by the Navy to continue reducing paper on ships is one that allows rapid access while denying users the ability to change the information. The system must also allow control over who has access to the information. CD-ROM disks can be distributed to each

department just as paper publications are distributed today. CD-ROM can be "read only" so that documents sent to the ship cannot be electronically changed. What is on each disk can be limited by who the disk is for. Yet, when implemented on Hypertext, each disk becomes vastly more effective in retrieval of information than paper text. By electronically storing manuals in Hypertext on disk, the efficiency of administration and operations can be greatly improved. Because electronic media allow importing of the information into word processors, information can be quoted, published, and used more efficiently in communications within the Navy than is done with the current system of hand copying the information into communications. To do so requires only the simplest of Hypertext applications.

IX. MODELING HYPertext FOR A PAPERLESS SHIP

A. SELECTING THE RIGHT PUBLICATION FOR A MODEL

Of all the publications common to the Engineering Department on Surface Ships, which publication provides the best opportunity for modeling Hypertext? In the Engineering Department of steam powered ships, the Boiler Water Feed Water Test and Treatment Manual, Volume 2 is one of the most frequently referenced publications. Water sampling of the boiler water occurs every four to eight hours, and with each sampling, the manual is referred to for deciding how the boiler should be chemically treated. Lab tests yield symptoms of problems occurring in the boiler. The manual recommends chemical treatments to control the problems that develop. Because of its importance to proper operation of the plant, the manual is one of the most familiar publications to naval engineers on steam ships.

This manual is full of graphics, formulas, explanations, definitions, and references to other publications. The manual has built-in redundancy to ensure information is not missed. It is the type of publication that governs the use of other publications. The manual is frequently referred to by other publications. For these reasons, it provides an excellent opportunity for studying Hypertext issues and for exploring how links are created and defined. Because of numerous

references to other publications, it provides an opportunity to explore the implications of linking libraries together into one hyperdocument.

B. SELECTING THE SOFTWARE TO IMPLEMENT THE MODEL

Unlike many of the experimental Hypertext systems, GUIDE is simple, inexpensive, and commercially available. By choosing GUIDE to implement the model, I was able to demonstrate Hypertext on a software product that costs under \$300.00 and on inexpensive low-end Personal Computer hardware. GUIDE is designed for the mass market, and for novice computer users. It is designed specifically for the purpose of displaying documents on screens in the "best" way possible. (Brown, 1986, p. 33) Before GUIDE, there had been a tendency to implement Hypertext only on expensive hardware. GUIDE demonstrates that Hypertext does not depend on hardware or on operating system. The software is available for most standard operating systems like Unix, MS-Dos, and Apple MacIntosh. (Brown, 1986, p. 34) GUIDE is the software of choice for this thesis because it is specifically designed for presenting documents electronically, is inexpensive, and is readily available commercially.

X. GUIDE: INEXPENSIVE, COMMERCIAL HYPERTEXT SOFTWARE

GUIDE has particular application to modeling electronic storage of reference material in a Paperless Ship. It is specifically designed for presenting documents like the one implemented in the model. GUIDE is designed to aid the reader when browsing documents. GUIDE does not include all of the features found in hypertext applications, but has the fundamentals. It is designed to be as simple as possible while applying hypertext principals to the display of reference documents.

Simple stand-alone Hypertext systems like GUIDE can have significant impact on the Navy. The Navy needs a simple, procurable system that requires minimal training, and allows user friendly retrieval of reference information. Ease of learning and ease of use are paramount. GUIDE fits the bill.

This thesis is not an attempt to sell GUIDE to the Navy but rather to prove that Hypertext is an existing technology that is currently available and can be applied to the Navy's need to store static reference material electronically. GUIDE is used only to demonstrate that any low-end personal computer provided with a hard disk, a mouse, and GUIDE software can become a hypertext work station.

A. GUIDE USES EXPANSION BUTTONS AND SCROLLS

By displaying hyperdocuments as a single scroll, GUIDE does not limit the frame size to the size of the screen. Hyperdocuments generated in GUIDE appear organized and lose the sense of a series of scattered pieces of text. The software preserves a linear approach while at the same time permitting an unstructured approach to the hyperdocument.

GUIDE implements hierarchical links by the use of the "Expansion-Button". Using this button, the reader works from a summary form of the document to an expanded form. The reader can expand to greater and greater detail as desired. At any time the reader can "undo" to a lesser degree of detail or return to the original summary. Clicking on an expansion button instantly replaces the button with the material linked to that button. This method differs from most other Hypertext applications. Because most applications use screen size as a limitation for each frame, selecting an embedded button totally replaces the screen with another screen. (Brown, 1986, p. 34)

What is elegant about the GUIDE method of using expansion over replacement is that "browsers" and graphical representations of position in the hyperdocument are not necessary. The presentation retains a linear feel. The user never loses his or her sense of direction or position within the document. The operation is like "folding." The user

unfolds information and then closes the information. By allowing an increasingly detailed presentation, GUIDE allows one document to cover a wide spectrum of readers. GUIDE presents information based on the user's need to uncover greater and greater detail. The information presented retains context because it is replaced in line. The user has no need to understand hierarchies, trees, or other computer science concepts. He or she simply folds and unfolds. Reversing the retrieval is easy and does not have to follow the order in which the information was retrieved. (Brown, 1986, p.36)

B. GUIDE ALLOWS FOR JUMPS BETWEEN HIERARCHIES

GUIDE also permits the user to jump from one hierarchy to another. The ability to leave a document based on a reference to another document or on an idea related to the document removes limitations provided by a hierarchy. Jumps are accomplished by use of the "Inquiry-Button". A reader can also jump back to where he or she came from. Inquiry Buttons replace the entire screen with a new screen, a method common to most Hypertext applications. The Inquiry Button allows GUIDE to be tailored to a screen per frame presentation if desired.

There is a danger in allowing a "goto" jump across reference space. Designers of GUIDE believe that the "goto" command in Hypertext is the root of navigational problems being argued about in other applications of Hypertext.

Getting lost is the major problem confronting Hypertext systems. Just as the "goto" in programming is uncontrolled and therefore dangerous to a program, so the "goto" in a large library, if uncontrolled, can cause the reader to become lost. (Brown, 1986, p. 36) GUIDE is designed for users who are approaching documents they are unfamiliar with and who are uncertain of exactly what they might require of the document. Therefore, by eliminating the "goto" of most Hypertext applications, GUIDE has eliminated one of the most elusive problems confronting Hypertext designers.

C. GUIDE HAS UNIQUE UTILITIES

When an out-of-line replacement is required, but not a jump, GUIDE provides the "Note-Button". The Note Button pops up in a separate window on the screen and is visible only while the button is held down. These buttons are handy for definitions, footnotes, and reference information. Reference information is information that does not add to the information, but explains or annotates the information.

The "find" command allows for string searches to find every incidence of a string within the hyperdocument. GUIDE also allows graphics to be displayed closely integrated with text. Buttons can be graphical instead of textual. Therefore, GUIDE users have to learn only a few procedures: using expansion buttons, note buttons, inquiry buttons, and find commands, and traveling through the document using scroll bars.

GUIDE permits the linking of other applications to the hyperdocument through use of whatever "Windowing" environment normally runs on the computer in use. For example, in the IBM version, GUIDE runs under Microsoft Windows. The Unix version runs under Unix Windows. Running GUIDE under a full version of Microsoft Windows instead of the run-time version provided with GUIDE, provides the author with "Command Buttons" to launch other applications like spreadsheets, wordprocessors, graphics drawing programs, and database management systems. Windows launches other applications, and manages the printing functions, word processing functions, and graphics functions within GUIDE. By using Windows to launch other applications, one can use GUIDE to launch modules of a Decision Support Systems and of an Expert System.

XI. BUILDING THE MODEL PUBLICATION

A. OPTICALLY SCANNING

To implement Hypertext, one must first convert paper documents to electronic documents. This requires either retyping the document or optically scanning the document into electronic form. Scanning can be done quickly if images are scanned as graphical images. Graphical scanning produces a clear and readable text, but the text cannot be manipulated or corrected. Graphics cannot be searched or automatically indexed. Graphical images are difficult to update and require much more storage in memory than does text. In this model, preserving text as text, and not as a graphical image, was considered to be an important part of preserving the capability for future updates and changes to hyperdocuments.

Graphical images were scanned using a hand held optical scanner costing \$200.00. The scanner was capable only of scanning images into bit map form. GUIDE accepts these images into the hyperdocument provided a full version of Microsoft Windows is running while the scanning is imported to the GUIDE document. Text was scanned using a mid grade intelligent scanning system. The text was scanned into a Xerox work station where it was converted to ASCII and imported into an MS-DOS format.

The Boiler Water Feedwater Test and Treatment Manuals, Volumes 1 and 2 were first copied from Microfiche, and then optically scanned onto disks. The first major concern in optically scanning documents is to prepare documents to be scanned. Documents must be clear and contain no graphical images. If such images, which include pictures, large font lettering, mathematical symbols, and markings made to the sides of pages, are not removed, the scanner will become confused as it tries to match the text. Lettering must be distinct, and fonts consistent. Preparation takes approximately 2 to 3 minutes per page.

After the user has obtained clear presentable copies, and after he has prepared the copies by removing graphics, he must train the text scanner to recognize the fonts and characters of the documents to be scanned. Training involves scanning one to two pages of the document. As the scanner finds letters it cannot recognize, it will indicate to the user what it is seeing and the user indicates to the scanner what letter the image represents. The process is laborious, but the speed of scanning will continue to increase as the scanner receives more training. Training the scanner is a necessary cost for each change of fonts. In this model, training the scanner was accomplished in eight hours.

After the scanner is trained by the user to recognize the fonts represented in the text, scanning can begin. Each page takes approximately 1.5 - 3 minutes to scan, depending on the

number of errors. While scanning documents, the user can make corrections to the text directly. The scanner indicates letters it is having difficulty recognizing and allows the user to identify the correct interpretation. Nevertheless, the error rate is still extremely high (10 to 15 errors per line). Because of the error rate, extensive editing is required. Errors tend to follow consistent patterns. Nevertheless, retraining the scanner does not decrease the error rate.

Importing the ASCII text into a Word Processor dramatically improves the error correction rate. Word Processors have word search functions that can find misspelled words. They also can replace patterns of incorrect scans with correct patterns. These functions dramatically reduce the time required for error correction; nevertheless, the process is still time consuming. The time to prepare documents for scanning, to train the scanner, to optically scan the documents, to convert the images to ASCII, and finally, to import and correct the text in Word Processor, support arguments that retyping the documents from scratch at 60-70 wpm is more efficient than scanning. It is more difficult to convert documents to electronic form, than to convert them to Hypertext.

B. CONSTRUCTING HYPERDOCUMENTS

Potential authors who are without computer experience can learn GUIDE in under eight hours. Training individuals to

build Hypertext documents using GUIDE is a simple process. However, authors must keep in mind the concepts underlying the software. Hypertext follows a pattern of thinking. Constructing GUIDE hyperdocuments follows the same pattern. The document must first be broken into logical textual and graphical chunks. In the Boiler Water Feed Water Test and Treatment Manuals, this can easily be achieved by following existing conventions.

1. Step One: Use Existing Conventions

Hierarchies (titles and subtitles) are already established in the Table of Contents. By observing the paragraph and subject numbering systems, the author can exploit the conventions of the document. Technical manuals are written in chunks, numbered as paragraphs that belong to sections and subsections depending on content and ideas. Use of these chunks can be the first step in providing the primary layer of links from one group to another. Finally, the index can be used to generate direct links from a term to a paragraph.

Initially, I imported the Table of Contents for Volume 1 into GUIDE using the utilities provided. The Table of Contents became the umbrella governing access to the rest of the document. By following the hierarchy of sections and subsections already existing in the Table of Contents, the author can first import the main section headings and establish the first view of the document. Next, under each

section heading, the subsection headings can be imported. Subsections are an expansion of section headings. Under each subsection heading, the sub-sub headings can be imported. From these headings, the text and graphics belonging to the headings are imported and connected by way of the expansion links.

The resulting document is first seen by the user as a set of main section headings. By selecting one of the main section headings, the user clicks the mouse and expands that heading to reveal its sub headings. By selecting a particular subheading, the user expands the subheading to reveal either another layer of sub-subheadings or the actual text and displays belonging to the headings. The resulting document is a hierarchy of general detail to more specific detail depending on what the reader selects. Text and pictures are linked in a hierarchy from their appropriate titles to their governing section.

2. Step Two: Identify Jumps Between Hierarchies

After constructing the foundation document, the author can establish appropriate jumps between the chunks. The foundation document exists in a tree relationship. Detail is revealed as the user selects each consecutive branch of the tree. But to be Hypertext, the user must also be able to branch from one tree to another. From a particular chunk, the author must establish appropriate links to related chunks in other trees.

In the Boiler Water Feed Water Test and Treatment Manual, numerous references cite other paragraphs, tables, appendixes, other parts of the manual, or other manuals related to the material being read. These references reveal a relationship between one piece of information and another. Such references can be used to identify branches between hierarchies. For the model to be Hypertext, the reader must be able to jump to the information on the other end of these relationships. The reader must also be able to undo the selection and to return. In this way, the reader does not need to leave the publication to view other publications, or lose his or her place when studying related material. The author can easily identify these jumps in the model by searching the text for these references. He can then use the utilities in GUIDE to establish the appropriate link between the reference and its related chunk.

3. Step Three: Implant Appropriate Definitions and Displays

Once links are established between references and publications, the author searches the text to implant definitions and displays. GUIDE's utilities provide for creating hidden definitions--terms and pictures--that can be popped into view. By clicking the mouse where the "Note Button" appears and holding the mouse button down, the author can keep the window containing the definition or explanation visible. Wherever a word appears that should be annotated

with either a definition, a formula, a picture, a graph, or a chart, the annotation can be hidden from view until selected. Individuals not requiring these definitions would not be encumbered by their presence on the screen and would not have to select them. But individuals who need explanations, definitions, or graphical presentations to gain a complete understanding of a new subject, have immediate access to them.

4. Step Four: Continue Development Through Updates

As the manual is developed, authors can continue to update and change it by adding links to references as they are discovered. Text and graphics can then be searched by expert individuals familiar with the publications who are looking for relationships that require further detail and explanations, and for paragraphs that should be linked to other manuals where references are not specifically sighted. For example, the Boiler Water Feedwater Test and Treatment Manuals would benefit from direct connections to the Boiler Maintenance Manual, Principals of Naval Engineering, the Engineering Operating Sequencing System, Planned Maintenance System, and applicable technical drawings.

5. Step Five: Implement Applications that Aid the User

Finally, GUIDE can be used as the shell for a Decision Support System. The document can be searched for applications that enhance use of the information. In the Boiler Water Feedwater Test and Treatment Manuals, access to thinking tools

like a pop up calculator, notepad, and card file can be achieved through Windows. The author can create the ability to access data reports, spreadsheets, and models to assist analysis by using GUIDE and Windows to launch programs like database managers, spreadsheet software, word processors, model bases, and other software packages. The ability to link other applications under the umbrella of Hypertext allows the user to access the background information, the report generators, and the decision tools that relate to the information, without having to close files or to lose his place in the information.

C. RESULTS OF BUILDING THE MODEL

In conclusion, building Hypertext documents using simple document presentation systems like GUIDE requires minimal training and equipment. Constructors of electronically stored Navy technical manuals can exploit conventions already in use in paper-based documents: tables of contents, references, definitions, glossaries, indexes, and numbering systems. That way, the manuals retain a familiar shape and structure, along with the benefits of an underlying Hypertext capability.

The model shows that electronic retrieval can evolve from current paper systems to systems that are simple to use, operate, and understand. Personnel who use the document require minimal training. Once the document is produced, training personnel to use it can be accomplished in a short

one hour training session. Authors of hyperdocuments will require more. The GUIDE model successfully implements a simple user interface that preserves the look and feel of paper systems while expanding the usefulness of documents through electronic retrieval and immediate access to related information.

XII. CONCLUSION

The original ideal of Paperless Ships is a clear, concise strategy statement that mandates paper reduction and office automation on ships. Its intent is to alleviate combat units of the serious limitations imposed by paper. Nevertheless, paper eradication is an imprecise view of how to regain efficiency in shipboard administration and decision support. It is more appropriate to focus on effectiveness: use paper where paper is the best vehicle to accomplish the task, and use electronic media where they are the best vehicle to accomplish the task. Do not eliminate all paper; rather, eliminate inefficient methods of managing information.

This thesis shows that developing a library of knowledge, using Hypertext for information retrieval, fills a gap between MIS and Decision Support for unstructured problem solving. SNAP fulfills many of the Surface Navy's requirements for transaction processing and for tasks associated with Management Information Systems. Hypertext can eliminate the need for paper manuals and books on board surface ships. Whether or not Hypertext and SNAP can together successfully eliminate all paper is arguable.

Implementing the Boiler Water Feedwater Test and Treatment Manual Volume 1 demonstrates that Hypertext is a useful and feasible way of presenting manuals. It communicates the

attributes of Hypertext documents, and the efficiencies to be gained by use of Hypertext for information retrieval. A major difficulty with implementing Hypertext is the reduction of manuals to electronic form. The model demonstrates as a prototype that manuals, once digitized, are simple and require minimal training to use. The model proves that Hypertext can preserve the manuals in an electronic form that appears similar to the way manuals are used in paper form. The model also demonstrates that Hypertext can be used as the shell for a Decision Support System and is capable of launching other applications and reports for decision making.

By preserving the indexing, references, and subject-file numbering systems already standard within Navy technical manuals, the first generation of Hypertext manuals can be rapidly and easily achieved. The manuals can evolve. Updates can be issued regularly and include new links and relationships as they are discovered. As manuals come on-line, paper versions will be less useful. But whether or not paper-based manuals can be removed from ships remains an open question.

The model successfully demonstrates that implementation can be accomplished on familiar equipment and can parallel continued use of books until the implementation is complete. Developing Hypertext can be an evolutionary process. The model also demonstrates that Hypertext is not a hardware issue. The model demonstrates that Hypertext manuals can be

stored individually on floppy disks as well as on optical storage devices like CD-ROM, and can still be more useful than books.

Although the model demonstrates that Hypertext can be implemented on low-end hardware, it does not show how search speed degrades as the quantity of material to be searched increases. With CD-ROM, both the storage capability and the capability of interlinking documents could dramatically increase. The type of electronic media to be used to store manuals or the impact of the media on the retrieval system is not discussed. As a demonstration of a concept, the model says nothing about either the best method for producing manuals in mass or the best method of electronically storing manuals. A follow-on thesis could address the impact of the type of electronic media on Hypertext and how library size affects the search speed and usefulness of Hypertext systems when implemented on current Navy computer systems like those of the SNAP program.

This thesis does not discuss the actual impact Hypertext and electronic media will have on the productivity of the crew. A follow-on thesis should study the impact of electronic media on productivity and on organizational relationships in the shipboard environment. How to reduce resistance to automation is not discussed. Also not discussed is how computer-based information systems change the organizational structure when implemented.

Hypertext fills a gap in automation not addressed by SNAP: document presentation and support for unstructured decisions. This thesis demonstrates that for the user interface, Hypertext is a desirable retrieval system because it is simple, friendly, and has a familiar look and feel.

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Attn: Major Paul W. LeBlanc, USMC
Quantico, Virginia 22134

10. Naval Data Automation Command, Code 30 1
Attn: LCDR David Lind, USN
Washington Navy Yard
Washington, D. C. 20374-1662

11. Ben Mortagy, Code 54My 1
Administrative Sciences
Naval Postgraduate School
Monterey, California 93940-5000

12. Lt. Daniel A. Kellett, USN 2
Surface Warfare Officer School
Class 109
Naval Education and Training Center
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